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PREY OF THE SPIDER, *DICTYNA COLORADENSIS,* ON APPLE, PEAR, AND WEEDS IN CENTRAL WASHINGTON (ARANEAE: DICTYNIDAE)

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Abstract.—The cribellate spider, *Dictyna coloradensis* Chamberlin, constructed webs on the upper surface of apple and pear leaves (trees not treated with insecticide), and on weeds in adjacent, uncultivated ground, at a site in south central Washington. Prey found in *D. coloradensis* webs were assigned to one of three categories; pests, predators and parasitoids, or neutral in impact with respect to fruit trees. Pest taxa comprised 32%, predators and parasitoids 24%, and neutral groups 44% of 18,314 prey. Most prey were small, winged insects (length < 5 mm). Insects from 58 families in 10 orders were represented and small spiders in four families were occasionally trapped. Sciaridae and Chironomidae (Diptera) were the most numerous prey and made up 37% of the total. Most webs contained one or more of these flies and occasionally 25 or more were trapped. Alate aphids were the most frequently captured pest insects. Other pests included adults of the white apple leafhopper, the pear psylla, and thrips. Relatively non-mobile stages of the pests (leafhopper and pear psylla nymphs and apterous aphids) were less commonly found in the webs. Nineteen percent of all prey were parasitoid wasps, 14 families of which were identified. Known parasitoids of apple and pear pests were included. The only other predator or parasitoid taxon that comprised more than 1% of total prey was the Empididae (3%).

Key Words.—Arachnida, Araneae, spider, *Dictyna,* prey use, apple, pear.

The cribellate spider genus *Dictyna* is represented in the Nearctic region by more than 100 species (Roth 1993). *Dictyna* construct irregular mesh webs in a variety of situations, at times in considerable numbers and high densities (Chamberlin & Gertsch 1958, Heidger & Nentwig 1985). Species of *Dictyna* have frequently been reported from orchards where they are at times abundant. Muma (1975) found *D. florens* Ivie and Barrows common and widespread in Florida citrus where it constructed webs on leaves of orange and grapefruit. Putman (1967) reported *D. annulipes* Blackwall to be a common spider in Ontario, Canada peach orchards where it constructed webs on areas of rough bark. Also in Ontario, Hagley & Allen (1989) found *D. annulipes* to be the most abundant foliage-inhabiting spider in an apple orchard and they studied its prey utilization by examination of webs and assay of gut contents.

Dictyna coloradensis Chamberlin occurs throughout much of the central and northern United States and into the Northwest Territories of Canada. With females approaching 4 mm in length, it is among the larger species in the genus (Chamberlin & Gertsch 1958). Dondale (1956) reported *D. coloradensis* from apple trees in Nova Scotia, Canada. During 1997, 1998, and 1999 this spider was very abundant on foliage of apple trees at the USDA-ARS research farm near Yakima, Washington. Webs were less abundant on pear foliage. Large numbers of *D. coloradensis* also constructed webs on tall, dead stalks of annual weeds in adjacent, uncultivated ground in the spring, and later in the year utilized the current season's growth.

Webs of *D. coloradensis* were collected during 1997, 1998, and 1999 and their prey contents identified. Because spiders are considered generalist predators (Wise 1993), we were interested in determining the taxonomic range of prey captured and the relative proportions that fell into three broad categories. 1) Pests: Included taxa are generally regarded as plant pests although not all specimens were necessarily pests of apple and pear. 2) Predators and parasitoids: All predatory and parasitic groups were included although not all were known predators and parasitoids of apple and pear pests. 3) Neutral: Taxa in this category probably have little or no detrimental or beneficial impact on fruit trees.

Materials and Methods

This study was conducted at the USDA-ARS research farm, 26 km east of Yakima, Yakima County, Washington. Several small blocks of fruit trees are planted at the 130 ha farm. Other crops grown include asparagus and potatoes, but some ground has never been cultivated and native vegetation, dominated by big sagebrush, *Artemisia tridentata* Nuttall (Asteraceae), remains within and surrounds parts of the farm. Uncultivated ground with mixed native and introduced vegetation partly surrounded some of the tree fruit blocks. Fruit trees were not treated with insecticides.

Pear and apple leaves and weed stems with *D. coloradensis* webs were placed in plastic vials with tight fitting lids and refrigerated until examined. Webs were immersed in 70% isopropyl alcohol in a petri dish and examined under 6.5×–50× for prey identification. Prey were identified to family, if possible, using keys in Borror, Delong, & Triplehorn (1976) and Goulet & Huber (1993). Exceptions included the following: Chironomidae and Sciaridae, the most abundant Dipteran prey, were difficult to distinguish when large numbers were present and specimens were damaged and entangled in webbing. Many specimens were therefore categorized as unidentified Nematocera. These two families made up the vast majority of prey in this category. Cyclorrhaphous Brachycera were categorized as medium size muscoid flies if larger than *Drosophila* but smaller than a housefly, and as small muscoid flies if *Drosophila*-size or smaller. Many chalcidoid wasps were identified only to superfamily (Chalcidoidea) and many small, non-chalcidoid, parasitoid wasps were classified as unidentified parasitoid wasps because small size, damaged specimens, and entanglement in webbing made identification difficult.

Webs were collected from three apple varieties ("Fuji", "Golden Delicious", and "Red Delicious"), pears (mixed "Anjou" and "Bartlett" varieties), and dead weed stems in uncultivated land adjacent to the "Fuji" apples. Weeds were primarily tumble mustard, *Sisymbrium altissimum* Linnaeus (Brassicaceae), an introduced species. A total of 984 webs was examined, distributed among the plant types as indicated in Table 1. Five to 15 webs were collected from a plant type per sample date at one to two week intervals. The sampling periods were 22 May to 16 Oct 1997, 30 Mar to 3 Nov 1998, and 20 Jul to 1 Oct 1999. Each plant type was not sampled throughout each sample period.

Results

Web Placement.—Most webs on apple and pear were constructed on the upper, concave surfaces of leaves. The small webs of young spiders covered only 2 or 3 cm^2 and were usually near the leaf apex. Webs of older, larger individuals often

Table 1. Number of sample dates and total number of *Dictyna coloradensis* webs examined from different plants during 1997, 1998, and 1999.

Plant	No. of samples dates—No. of webs examined		
	1997	1998	1999
Apple–"Fuji"	11–141	19–192	—
Apple–"Golden"	10–57	10–56	—
Apple–"Red"	9–59	—	—
Pear	5–17	9–91	11–155
Weeds	—	18–216	—

covered most of the upper surface of a leaf. Leaves were up to 10 cm long. Prey accumulated in webs and older, larger webs contained up to 40 or more prey. Webs were occasionally found in the angle formed by two branches, among flower petioles, or between a leaf petiole and a branch. They were less visible in these locations and few were sampled. Webs on dead weed stalks were constructed among branches on the upper part of a stalk, 0.3–1.0 m above ground.

Prey Utilization.—Fifty-eight families of insects in 10 orders and four families of spiders were identified from webs of *D. coloradensis* (Table 2). Some taxa were represented by few specimens (two Ephemeroptera among 18,314 prey) whereas others made up a high proportion of prey in webs from all sources all three years.

Insects classified as neutral with respect to impact on fruit trees made up the largest proportion of prey items overall (7981 prey = 44%). Nematocerous Diptera, primarily Sciaridae (dark-winged fungus gnats) and Chironomidae (midges) were the most abundant prey of any kind (37% overall). Sciarids and chironomids were present throughout the season and were found in a majority of webs regardless of source. Webs occasionally contained 25 or more of these small insects. Other taxa of neutral prey rarely comprised more than 1% of the total from a plant in one year. Small muscoid flies, however, made up 5.4% of prey in webs from "Golden Delicious" in 1997.

Aphids were the most numerous pest insects found in *D. coloradensis* webs, and alates were generally much more abundant than apterous forms. Five to 30% of the total insects found in webs from each plant type each year were aphids. Aphids were not identified to species because of the large number captured and their often poor state of preservation (discoloration, damage, dehydration). Several species are considered pests of apple in Washington and many appeared to be green apple aphid, *Aphis pomi* DeGeer, or the nearly identical spirea aphid, *A. spireacola* Patch. Apple/spirea aphid colonies were abundant on developing apple shoots all three years. Thrips (Thysanoptera) made up 5–11% of total prey in the samples from fruit trees but were more abundant in webs on weeds (22%). The western flower thrips, *Frankliniella occidentalis* (Pergande) is the only species listed by Beers et al. (1993) as a pest of tree fruit in Washington. A pale, yellowish insect, its host range includes several fruit trees, alfalfa, potatoes, and numerous species of weeds (Beers et al. 1993). Thrips were not identified to species due to small size, entanglement in webbing, and poor preservation. The vast majority, however, were pale, yellowish insects, in general resembling *F. occidentalis*. White apple leafhopper adults, *Typhlocyba pomaria* McAtee, were most abundant

Table 2. Total number of prey items in each taxon found in *Dictyna coloradensis* webs from apples, pears, and weeds.

Prey taxa	Apples	Pears	Weeds
Neutral impact taxa			
Chironomidae	195	163	745
Sciaridae	760	238	112
Bibionidae	25	0	94
Psychodidae	6	2	1
Scatopsidae	1	4	1
Simuliidae	1	3	0
Tipulidae	1	1	0
Nematocera–unidentified	2873	1022	590
Stratiomyidae	1	0	0
Therevidae	4	0	0
Bombyliidae	2	0	3
Drosophilidae	175	78	28
Phoridae	38	29	8
Conopidae	0	0	1
Small muscoid flies	375	100	87
Medium muscoid flies	30	26	10
Diptera—unidentified	0	0	5
Halictidae	12	7	0
Chrysididae	1	0	0
Tenthredinidae	0	0	1
Scarabaeidae	2	0	2
Coleoptera—unidentified	6	1	6
Aleyrodidae	1	0	0
Fulgoroidea	0	0	1
Lygaeidae	6	0	17
Hemiptera—unidentified	2	1	3
Psocoptera	42	18	9
Ephemeroptera	1	1	0
Pest taxa			
Aphididae—alate	1549	1011	431
Aphididae—apterous	230	67	5
Typhlocyba pomaria	289	5	2
Other Cicadellidae	18	1	2
Cacopsylla pyricola—adults	3	165	1
Cacopsylla pyricola—nymphs	0	50	0
Phyllonorycter elmaella	193	37	3
Lepidoptera—unidentified	3	0	3
Caterpillar	0	2	0
Miridae—*Lygus* sp.	2	0	3
Miridae—*Campylomma* sp.[a]	12	1	1
Thysanoptera	687	281	777
Acari	3	5	0
Predator and parasitoid taxa			
Cecidomyiidae	6	5	4
Empididae	387	132	6
Dolichopodidae	11	4	0
Pipunculidae	25	9	3
Tachinidae	6	6	1
Syrphidae	2	0	0
Braconidae	349	56	81
Ichneumonidae	76	16	18

Table 2. Continued.

Prey taxa	Apples	Pears	Weeds
Pnigalio flavipes	177	63	3
Trechnites insidiosus	0	50	0
Mymaridae	641	17	20
Encyrtidae	0	0	1
Chalcidoidea—unidentified	713	373	106
Platygastridae	40	16	21
Scelionidae	25	14	5
Ceraphronidae	73	14	16
Megaspilidae	2	2	1
Proctotrupidae	3	4	1
Dryinidae	1	1	2
Bethylidae	3	0	6
Diapriidae	1	0	3
Cynipoidea	12	3	1
Parasitoids—unidentified[b]	249	94	123
Sphecidae	8	8	0
Formicidae	15	7	133
Vespidae	1	1	0
Staphylinidae	39	4	35
Carabidae	2	0	3
Coccinellidae	2	1	0
Hemerobiidae	6	2	0
Chrysopidae	2	0	0
Anthocoridae—*Orius*	27	5	7
Nabidae—*Nabis*	0	0	1
Lygaeidae—*Geocoris*	0	0	5
Miridae—*Deraeocoris*	2	2	0
Salticidae	7	1	1
Linyphiidae—*Erigone*	13	2	2
Linyphiidae	10	9	17
Thomisidae	2	0	0
Oxyopidae	6	1	0
Araneae—unidentified	0	2	0
Prey totals	10,493	4243	3578

[a] *Campylomma* also act as predators by feeding on such pests as aphids and mites.
[b] Category includes only hymenopteran parasitoids.

in webs from "Fuji" apples during 1998 when they comprised nearly 5% of all prey. *Typhlocyba* comprised less than 2% of total prey in the other samples, and nymphs were rarely captured. Adult, western tentiform leafminer, *Phyllonorycter elmaella* Doglanar and Mutuura, made up 1–2% of the prey in each tree fruit sample, but only three of 3578 prey in webs from weeds. Pear psylla, *Cacopsylla pyricola* (Foerster), a serious pest of pear in the Pacific Northwest, made up 5.5% of the prey in *D. coloradensis* webs from pear during 1997, just under 1% in 1998, and 8% in 1999. Psylla populations at the research farm were low during 1998, probably accounting for their rarity as prey despite the greater number of webs examined compared to 1997. Psylla numbers were higher during 1999 when leaves and shoots were often sticky with honeydew, and this was reflected in the number captured in *D. coloradensis* webs. Most captured *C. pyricola* were adults, although a substantial number of nymphs fell victim in 1999 (50 nymphs, 134 adults). However, it was difficult, at times, to distinguish psylla nymphs from their cast skins.

Small, hymenopterous parasitoids were the most abundant predatory and parasitoid insects trapped in *D. coloradensis* webs. They comprised 12% to 28.6% of total prey in yearly samples from each of the plants. Hosts of many of the parasitoids were not determined or are unknown, some are probably hyperparasitoids, and some probably occurred only incidentally in the fruit trees. Known parasitoids of apple and pear pests were, however, captured. *Pnigalio flavipes* (Ashmead) (Eulophidae), the most common parasitoid of the western tentiform leafminer in the Pacific Northwest (Beers et al. 1993), made up 1%–2% of total prey in samples from fruit trees. It was rarely found in webs on weeds. Mymaridae (fairyflies) were captured in substantial numbers in webs on "Fuji" (449 = 11.9%) and "Golden Delicious" (132 = 6.6%) during 1998. Both represented large increases over numbers found in 1997. Mymarids in the genus *Anagrus* are important egg parasitoids of the white apple leafhopper and parasitism rates of up to 70% have been reported in unsprayed orchards (Beers et al. 1993). Many mymarids found in webs on apple may have been leafhopper egg parasitoids. Two percent of the insects in webs from pear during 1999 were *Trechnites insidiosus* (Crawford) (Encyrtidae), the most important parasitoid of pear psylla in western North America (Beers et al. 1993).

Other taxa of insect predators and parasitoids rarely comprised more than 1% of the total prey in webs from a given plant type (Table 2). Empididae, however, made up 7.5% (233 flies) of the prey found in webs on "Fuji" apple in 1997. Spiders also were infrequently snared in *D. coloradensis* webs (< 1% of prey in samples from any of the plant types) and were small, either immatures or taxa of small body size.

Discussion

The diversity of prey captured by *D. coloradensis* is in agreement with the idea of spiders as generalist predators (Wise 1993). Individual species, however, utilize a restricted range of available prey depending on factors such as spider size, hunting strategy, and web size and placement (Marc & Canard 1997). Spiders generally feed on prey smaller than themselves (Jackson 1977, Nyffeler et al. 1994). This was true of *D. coloradensis,* the vast majority of whose prey consisted of insects less than 5 mm in length. The predominant use of small prey has also been noted in *D. segregata* (Nyffeler et al. 1988), *D. arundinacea* (Heidger & Nentwig 1985), and 11 species, including *D. coloradensis,* studied by Jackson (1977). Large and dangerous prey were, however, captured occasionally. Two worker yellow-jackets (*Vespula* sp.) were found in 1997 webs and on 26 Apr 2000 a recently captured worker honeybee, *Apis mellifera* L., was noted in the web of a female on a dead weed. The spider was feeding on the bee at the time. Overall, however, few prey larger than a housefly were found in the webs. No codling moth, *Cydia pomonella* (L.) or leafrollers, *Pandemis pyrusana* Kearfott, were captured. Both are important apple pests in Washington (*C. pomonella* was very abundant at the farm in 1997–1998), but at adult lengths of 12 mm or more, they may be too large to be readily subdued by *D. coloradensis* webs.

A given species of spider may not utilize all stages in a prey species' life cycle to equal degrees (Marc and Canard 1997). This was true for several prey species of *D. coloradensis,* most or all of whose life cycles are spent on the fruit trees. Adult white apple leafhopper, adult pear psylla, and alate aphids were common prey but immature leafhoppers and psylla and apterous aphids fell victim less frequently. This is probably related to the relative mobility of different stages of the prey and their locations on the plant. White apple leafhopper and pear psylla adults are mobile and fly readily when disturbed. They would appear much more likely to blunder into webs than the more sedentary nymphs. Also, white apple leafhopper nymphs generally feed on the lower surface of the leaf (Beers et al. 1993) whereas *D. coloradensis* webs are constructed almost exclusively on the upper surface. Psylla nymphs, with their flattened body form and leaf-surface hugging habits were often found alive beneath *D. coloradensis* webs—apparently able to avoid entanglement in the silk. Alate aphids, although not strong fliers, are more mobile than the apterous forms and again must be more likely to come into contact with webs. Green apple aphid colonies generally develop on succulent, young tissue and are found on growing shoot tips, shoot stems, and the undersides of leaves (Beers et al. 1993). Thus the sedentary, apterous forms are less likely to come into contact with *D. coloradensis* webs.

Dictyna coloradensis webs trapped many small (1–3 mm), hymenopterous parasitoids (19.1% of all prey). Some parasitoids were observed crawling over leaf surfaces, which must often bring them into contact with webbing. This is true of *P. flavipes* and *T. insidiosus* females, both of which search leaf surfaces for hosts (Beers et al. 1993), and many became entangled in the webs. Nearly the same number of male *P. flavipes* (122) were captured as females (118). *T. insidiosus* is thelytokous in the western states (Unruh et al. 1995) and males were not found in the webs. Thirteen percent of the prey of *D. arundinacea* (L.) consisted of small parasitoid wasps (Heidger & Nentwig 1985).

Predatory insects, and parasitoids other than Hymenoptera, were infrequently found in *D. coloradensis* webs. *Deraeocoris* spp. (Miridae), for example, are important predators of pear psylla (Beers et al. 1993) and were abundant on the pears during 1999. Yet *Deraeocoris* accounted for only 0.09% of the prey in webs on pear during 1999. Aphid predators such as Coccinellidae and Chrysopidae, often abundant in unsprayed orchards with high aphid populations, made up similarly low percentages of prey in all samples. Such insects, perhaps because of size, behavior, and distribution on the plants may not be very vulnerable to entanglement in *D. coloradensis* webs.

Other spiders were infrequent prey in *D. coloradensis* webs. The low number taken (0.4% of total prey) is in accord with Nyffeler's (1999) findings that web building spiders are 99% insectivorous whereas hunting types take a higher proportion of other spiders. Jackson (1977), for example, found that 27% of the prey of *Phidippus johnsoni* (Peckham and Peckham) (Salticidae) was other spiders.

Capture of beneficial insects and spiders by *D. coloradensis* (intraguild predation in a broad sense) was substantial in terms of the overall numbers captured. However, the hosts of many of the parasitoids may not be orchard pests and their capture may have little negative impact on orchard ecology from a pest management standpoint. Greenstone (1999) noted that the net effect of intraguild predation can only be determined by examining the system in the presence and absence of the predator. Although intraguild predation and competitive interactions among predators may in some cases disturb natural pest control, in others they may promote greater spider biodiversity and allow spiders to survive periods of low prey density (Sunderland 1999).

Several studies have shown that small Diptera are important components in the diet of *Dictyna* spiders. Several families of small flies made up 50% of the prey captured by *D. arundinacea* in a meadow in Germany (Heidger & Nentwig 1985) and small Diptera dominated the prey of each of 11 *Dictyna* species studied by Jackson (1977). Chironomidae comprised 70.7% of the total prey of *D. annulipes* in an apple orchard in Ontario, Canada (Hagley & Allen 1989), and a diverse array of small Diptera were important components in the diet of *D. coloradensis* in Washington. The abundance of these small flies was likely important in supporting the high population of *D. coloradensis* observed during this study. Also, their presence during much of the season may help fill in gaps in availability of other types of prey, as noted by Sunderland (1999) with respect to intraguild predation.

Clearly, *D. coloradensis* is a polyphagous predator that includes a wide range of insects in its diet. Prey selectivity is based primarily on size and activity level—small, active insects are most heavily utilized. Small, active pests of apple and pear are taken in substantial numbers, but unfortunately, from a pest management standpoint, known parasitoids of some pests are also trapped, sometimes in considerable numbers.

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